Baumer

Baumer HXC13

User's Guide for Digital High Speed Camera

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1. Introduction

The CMOS high speed camera HXC13 is a high resolution camera with 1280x1024 pixel. Benefits of CMOS technology are high speed, random access to pixels with free programmability and low power.

The camera uses industry-standard C-Mount, F-Mount or M42 lenses. The sensor diagonal is 22.9 mm with square pixels measuring 14 µm.

Free programmability means that the user is free to define the region of interest (ROI) by size and position and the speed of data output. The frame rate can be selected between 1 fps and several thousand fps depending on resolution and video data width.

With a resolution of 1280 x 1024 pixel, 500 fps can be output via the “Full CameraLink®” Interface.

1.1. Top Level Specifications

- High resolution: 1280x1024 pixel CMOS Sensor
- up to 1024 gray levels (10bit resolution)
- up to 500 full frames/sec
- arbitrary region of interest
- very high sensitivity
- 14 µm square pixels
- electronic “Freeze Frame” shutter
- low blooming
- programmable via CameraLink® serial interface
- asynchronous trigger
- small, compact housing
- wide power supply range

1.2. Electronic "Freeze Frame" Shutter

Preceding exposure, the contents of all light sensitive elements is cleared. When exposure terminates, accumulated charge is transferred to an analog memory associated which each pixel. It stays there until it is read out (and discharged) by the A/D conversion cycle.

As all light sensitive elements are exposed at the same time, even fast moving objects are captured without geometric distortion.

2. Hardware

2.1. Dimensions

2.1.1. Baumer HXC13 with F-Mount

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
HXC13 F-Mount	1/4"	1280x1024	500

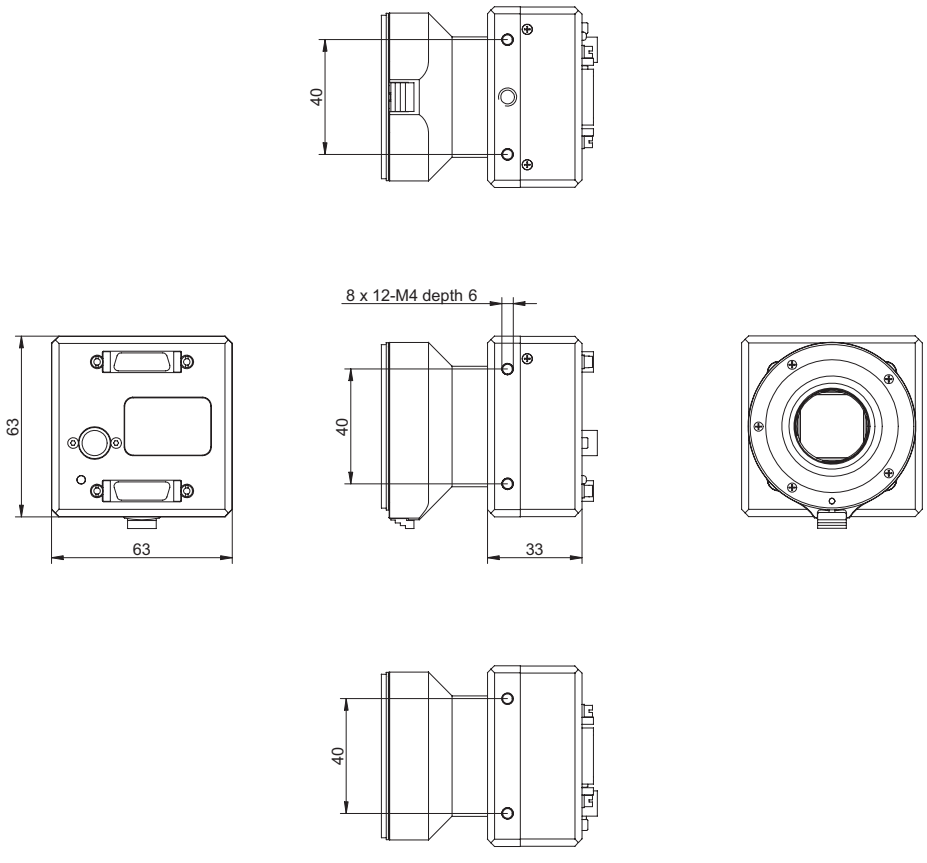
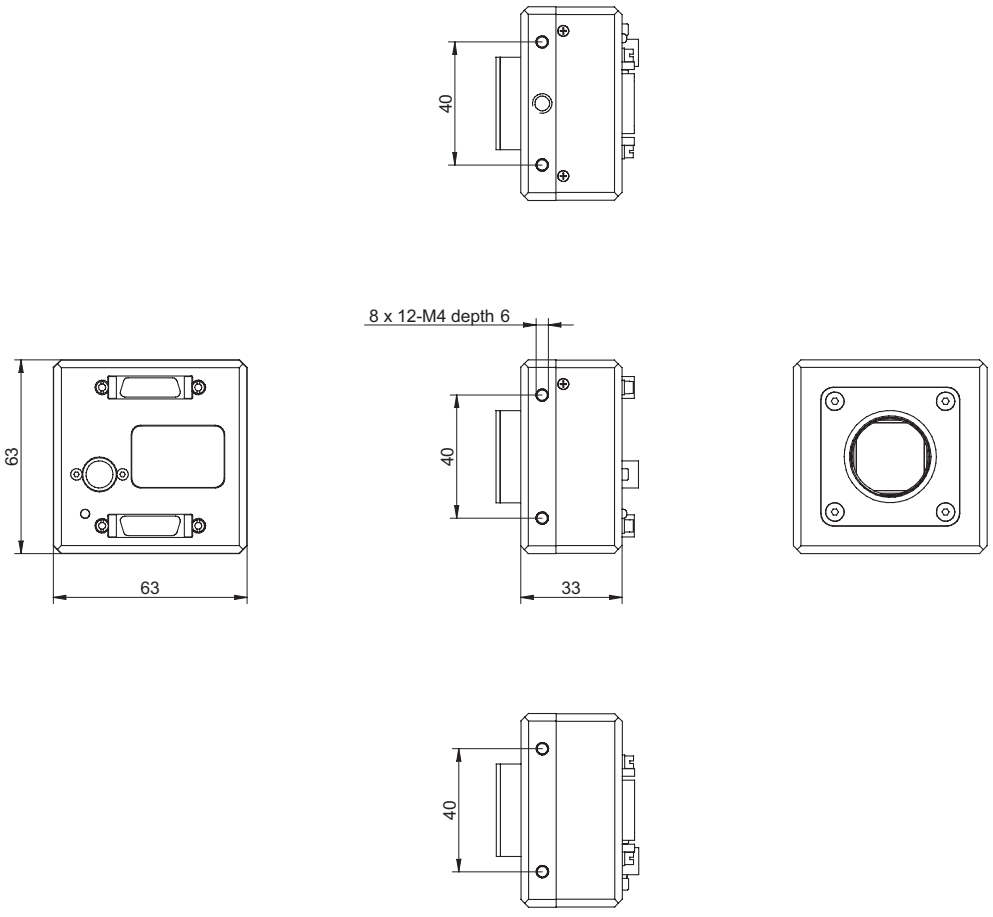


Figure 1 ►
Dimensions of Baumer HXC cameras with F-Mount.

2.1.2. Baumer HXC13 with C-Mount

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
HXC13 C-Mount	1/4"	1280x1024	500



◄ **Figure 2**
Dimensions of Baumer HXC cameras with C-Mount.

2.1.3. Baumer HXC13 with M42-Mount

Camera Type	Sensor Size	Resolution	Full Frames [max. fps]
HXC13 M42-Mount	1/4"	1280x1024	500

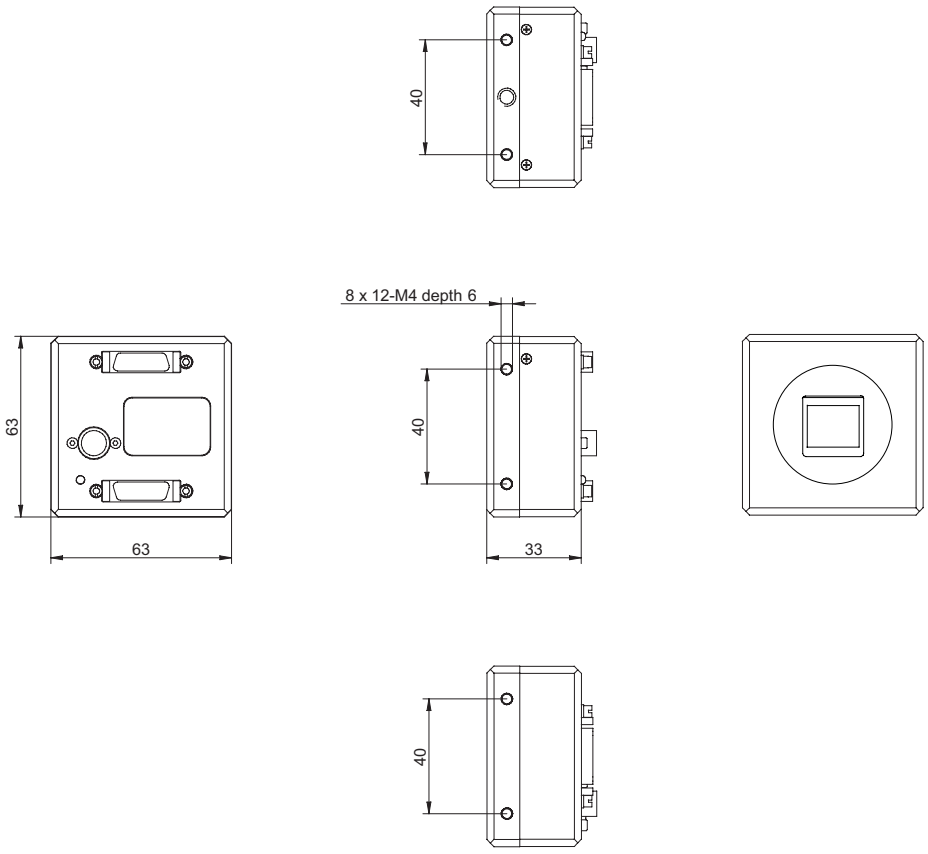


Figure 3 ►
Dimensions of Baumer HXC cameras with M42-Mount.

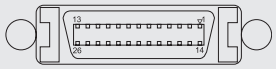
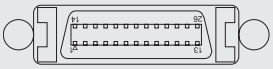
2.2. CameraLink® Interface

CameraLink® is designed for digital cameras in machine vision applications. A "Full CameraLink®" interface can transfer up to 80 bits of data at a rate of max. 680 Mbytes/sec.

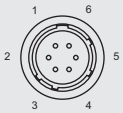
2.3. Serial Interface

The communication via the serial interface is incorporated in the "Base CameraLink® " interface.

2.4. Pin-Assignment

Base CameraLink®				Full CameraLink®			
							
Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	GND	14	GND	1	GND	14	GND
2	X0-	15	X0+	2	Y0-	15	Y0+
3	X1-	16	X1+	3	Y1-	16	Y1+
4	X2-	17	X2+	4	Y2-	17	Y2+
5	XCLK-	18	XCLK+	5	YCLK-	18	YCLK+
6	X3-	19	X3+	6	Y3-	19	Y3+
7	SERTC+	20	SERTC-	7	100 Ω term.	20	100 Ω term.
8	SERTFG-	21	SERTFG+	8	Z0-	21	Z0+
9	CC1-	22	CC1+	9	Z1-	22	Z1+
10	CC2+	23	CC2-	10	Z2-	23	Z2+
11	CC3-	24	CC3+	11	ZCLK-	24	ZCLK+
12	CC4+	25	CC4-	12	Z3-	25	Z3+
13	GND	26	GND	13	GND	26	GND

Power Supply	
Power VCC	8 VDC ... 24 VDC
Power Consumption	5 W

Power Supply					
					
Pin	Signal	Pin	Signal	Pin	Signal
1 (white)	VCC	3 (green)	STRB	5 (grey)	GND
2 (brown)	VCC	4 (yellow)	DGND[1]	6 (pink)	GND

[1] DGND - digital GND for signal STRB

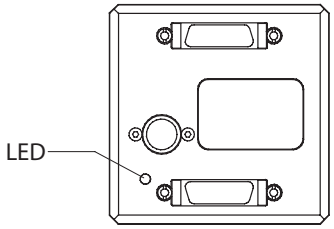
Notice

Before applying power to the camera we strongly recommend to verify the used pins of the power connector, the polarity (+/-) of the leads and the supply voltage.

The camera may only be used with a supply voltage according to the camera specification (8 VDC .. 24 VDC). Connecting a lower or higher supply voltage, AC voltage, reversal polarity or using wrong pins of the power connector may damage the camera. If doing so, the warranty will expire immediately.

2.5. LED Signaling

The operation conditions of the camera are signaled by the dual color LED on the backside of the camera.



Signal	Meaning
off	▪ Camera is de-energized. ▪ If LED is off, despite the camera is powered, data is stored to the internal EEPROM. No (other) activity is possible.
yellow	The camera is configuring the internal FPGA. No other activity is possible.
green	The camera is fully operational.
red	▪ The camera's microcontroller detected a configuration error. ▪ The camera's FPGA could not be loaded. The camera is not functional. Try reload configuration data.
red flash	▪ The camera's microcontroller or FPGA is loading data. ▪ Camera verifies checksum. No other activity is possible.

2.6. Sensor Specification

In Baumer HighSpeed cameras HXC13 LUPA 1300-2 CMOS sensors from Cypress Semiconductor Corporation are employed.

The spectral response of these sensor are displayed in the charecteristic curve below.

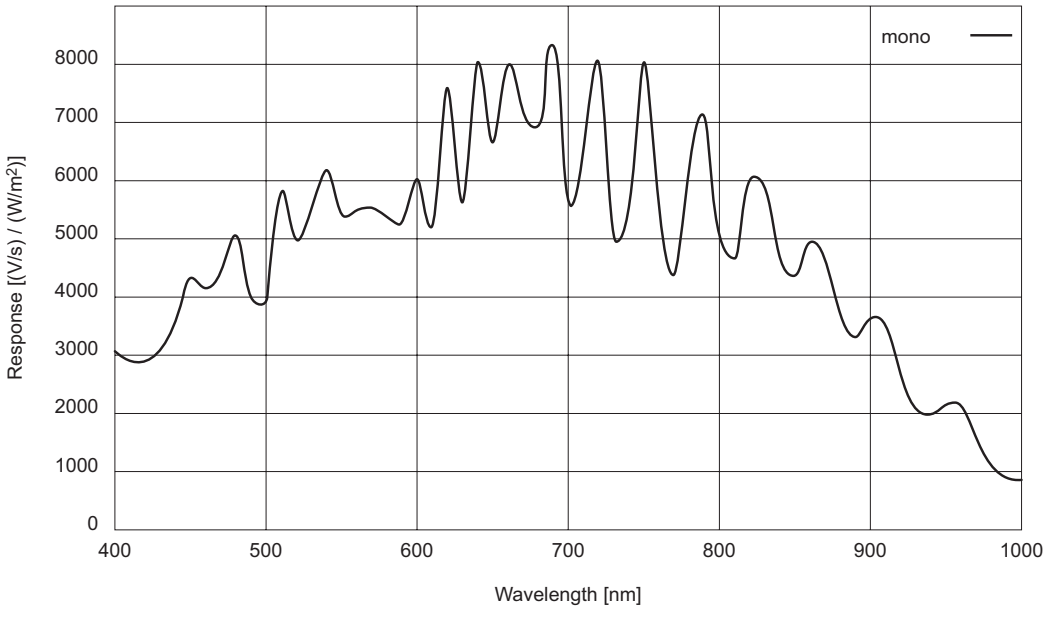


Figure 4 ►
Spectral sensitivities for sensors in Baumer HXC13 cameras.

3. Getting Started

Before starting to operate the camera, make sure that the following equipment is available:

- Baumer HXC13 camera
- required lens
- Baumer Software CD
- Image processing system, e.g.: PC and Software
- 1 CameraLink® cable (2 for Full CameraLink® operation)
- 1 Power supply 12VDC, 0.75A min
- 1 power cable

4. Initial Setup

Baumer HighSpeed cameras are delivered with initial parameters and therefore do not need to be configured via the serial link.

4.1. Serial Number and Firmware Revision

Serial number and firmware revision is provided in the cameras non-volatile memory. Use `:v` command to read serial number and firmware revision. The serial number is also marked on the type plate of the camera.

4.2. PowerUpProfile

The PowerUpProfile is the content of all camera registers to be loaded from non-volatile memory after power up.

4.3. Camera profile

The actual set of parameters is called Camera Profile. All changes of parameters by the serial link is reflected in the Camera Profile. On command the Camera Profile is saved to 8 user profiles or the PowerUpProfile. It is loaded from the PowerUpProfile, 8 user profiles or 8 factory profiles. The camera profile is volatile and must be stored to the PowerUp-Profile to be reactivated on next power up.

4.4. Factory Profiles

The factory profiles can be read but not written by the user. They are factory preset to the settings described below.

Profile No.	Video Data Width [Mbytes/sec]	Resolution	Full Frames [max. fps]	Mode	Camera Link Configuration	Pixelclock [MHz]
0	148	640 x 480	405	2x10	Base	80
1	172	1280 x 1024	110	2x10	Base	80
2	119	640 x 480	405	2x8	Base	80
3	138	1280 x 1024	110	2x8	Base	80
4	297	640 x 480	811	4x10	Medium	80
5	353	1280 x 1024	226	4x10	Medium	80
6	468	640 x 480	1599	8x8	Full	80
7	540	1280 x 1024	432	8x8	Full	80

4.5. User Profiles

The user can store up to eight User Profiles in non volatile memory. All load or write commands exchange data between the Camera Profile and one of the eight user profiles.

Profile No.	Video Data Width [Mbytes/sec]	Resolution	Full Frames [max. fps]	Mode	Camera Link Configuration	Pixel-clock [MHz]
0	148	640 x 480	405	2x10	Base	80
1	172	1280 x 1024	110	2x10	Base	80
2	119	640 x 480	405	2x8	Base	80
3	138	1280 x 1024	110	2x8	Base	80
4	297	640 x 480	811	4x10	Medium	80
5	353	1280 x 1024	226	4x10	Medium	80
6	468	640 x 480	1599	8x8	Full	80
7	540	1280 x 1024	432	8x8	Full	80

4.6. PowerUp Profile

The user can store one PowerUpProfile in non volatile memory.

Profile No.	Video Data Width [Mbytes/sec]	Resolution	Full Frames [max. fps]	Mode	Camera Link Configuration	Pixel-clock [MHz]
c	144	1280 x 1024	111	2x8	Base	80

5. Configuration

The content of all camera registers is called a profile. There is space in non volatile memory for 17 profiles: The PowerUpProfile, 8 user profiles and 8 factory profiles.

Any change of a specific register through the serial interface is immediately processed and written to the volatile part of the memory and gets lost when power goes down. A command must be used to store the actual setting in non volatile memory. After power-up the PowerUpProfile is loaded from the non-volatile to the volatile part of the memory. A load or write command exchanges data between the CameraProfile and one of the eight user profiles. The eight factory profiles can be read but not be written by any command. All values are given in hexadecimal notation, e.g.: `0xff` or `0ffh = 255`.

5.1. Commands

ASCII strings are used to change camera parameters. All commands start with a colon followed by the command character.

Notice

Note that the commands are case sensitive.

The baudrate can not be saved. Therefore the camera always defaults to 9600 baud after power on or reset.

After a command has been recognized, processing is immediate for all commands but the save command (`:p`). This needs a EEPROM write time. An answer is provided with read type commands (e.g. `:v, :w`), or, if the command acknowledge flag is set, after processing of each command an ACK or NAK character. Processing of wrong commands is stopped immediately on recognizing the error. A new command must start with a colon.

All unknown commands will return NAK. After the colon the maximum time between the characters must not exceed 2.7 sec., else the command will terminate with NAK. This prevents the parser from hanging in the input if a command is not entered complete.

Most of the commands can return the actual value by sending '`?`' as parameter. Some commands then also return the actual value range.

5.2. Table of Commands

Syntax	Value Range	Answer	Comment
:A<x>	<x> = y,Y,n,N	--[1]	command acknowledge flag yes or no
:b<x>	<x> = 0...4	--[1]	Select baudrate 0 = 9600 (default), 1 = 19200, 2 = 38400, 3 = 57600, 4 = 115200
:B	--	OK or ERROR: xxxx[2]	Send last error to PC (max. 45 chars)
:c	--	--[1]	Reset camera and load power up profile
:d<aaa><bbb><ccc><ddd> :d?	<aaa> = x-start 0…4FE$_{hex}$ <bbb> = y-start 0…3FE$_{hex}$ <ccc> = x-width 2…500$_{hex}$ <ddd> = y-height 1…400$_{hex}$	--[1] or <aaa><bbb> <ccc><ddd>[2]	Set ROI start- and endcoordinate (data area)
:D<xxxx> :D?	<xxxx> = 0, 400…1000$_{hex}$	--[1] or <xxxx>[2]	Digital gain 400 = gain 1x , 1000 = gain 4x, 0 = gain correction off
:f<n>	<n> = 0…7 for FULL <n> = 0…3 for BASE	--[1]	Load factory profile <n>
:g<n>	<n> = 0…7, c for FULL <n> = 0…3, c for BASE	--[1]	Load user profile in bank <n> -- bank "c" = PowerUpProfile
:h<n> :h?	<x> = 0…2	--[1] or <x>[2]	Shutter 0 = free run, 1 = PWC, 2 = timer
:H<n> :H?	<x> = 0, 1	--[1] or <x>[2]	Set shutter pulse polarity 0 = positive edge, 1 = negative edge
:i<s><x> :i<s>? :i<s><xx> :i<s>?	<s> = 'n' → <x> = 1…3 <s> = 'd',' t' → <xx> = 1…63$_{hex}$	--[1] or <x>[2] --[1] or <xx>' ' <yy>-<zz>[2]	1 = normal shutter, 2 = dual slope, 3 = triple slope set d = dual, t = triple slope in percent of shutter time get actual slope time and allowable range
:k<xx> :k?	<xx> = 32…C8$_{hex}$	--[1] or <xx>[2]	Set blacklevel; value 80h is default; increase or decrease value slightly to adjust blacklevel
:K<z><x> :K<z><xxx> :K<z>?	<z> = 'n' → <x> = 0…1 <z> = 'v' → <xxx> = 0…3FF$_{hex}$	--[1] or <x>[2] or <xxx>[2]	Enable or disable threshold with :Kn1 or :Kn0 or set threshold value with :Kv<xxx>
:l<n><y> :l ?	<n> = 0…3 <y> = 1…f$_{hex}$	--[1] or <ny>[2]	Select ROI move mode with external CCx input ; see command description
:L<z><xxx><yyy> :L<z>? :L<z><a>	<z> = 1…3 or 'n' <xxx> = x-start 0…4FE$_{hex}$ <yyy> = y-start 0…3Fe$_{hex}$ <a> = 0…3	--[1] or <xxx><yyy>[2] or <a>[2]	Select multiple ROI's ; see command description
:M<x> :M?	<n> = 0…6 for FULL <n> = 0…1 for BASE	--[1] or <n>[2]	Set modus 0 = 2x8, 1 = 2x10, 2 = 16x1, 3 = 2x8 mask, 4 = 4x10, 5 = 8x8, 6 = 10x8
:n<x> :n?	<x> = 0…1	--[1] or <x>[2]	0 = Power down + testimage 1 = normal operation

:N<x>	<x> = 0…1	--[1] or	Enable = 1 or disable = 0
:N?		<x>[2]	FPN correction
:o<x> :o?	<x> = 0…3	--[1] or <x>[2]	Invert readout in x- and or y-direction
:O<x> :O?	<x> = 0…7	--[1] or <x>[2]	Non destructive readout 1...7 frames
:p<n>	<n> = 0…7, c for FULL <n> = 0…3, c for BASE	--[1]	save actual profile in bank <n> -- takes about 2 sec. -- Bank „c“ = PowerUpProfile
:q<xxxxxx>	<xxxxxx> = $1…13880_{hex}$	--[1]	Set framerate
:q?		or <xxxxxx>' '<ss>'-'<zzzzzz>[2]	get actual framerate, and possible framerate range for actual ROI
:R<xx> :R?	<xx> = $3c_{hex}$, 41_{hex}, 46_{hex}, $4b_{hex}$, 50_{hex}	--[1] or <x>[2]	Reduce pixelclock from 80 MHz to 60, 65, 70 or 75 MHz
:SC<xxx><yyy><rrr><www>	<xxx> = $0…500_{hex}$; <yyy> = $0…400_{hex}$ <rrr> = $1…300_{hex}$; <www> = $1…400_{hex}$	--[1]	Shape circle create
:SM<aaa><dddd>	<aaa> = $0…3ff_{hex}$; <dddd>= $0…ffff_{hex}$	--[1]	Shape mask load
:SE		--[1]	Shape erase
:SV<n>	<n> = 0…1 , ?	--[1]	Shape visible on/off
:t<xxxxxx> :t?	<xxxxxx> = $2…F4240_{hex}$	--[1] or <xxxxxxx>' '<ss>-<zzzzzz>[2]	Set shutter time in µs get actual shutter time and possible shutter time range for actual framerate
:T	--	(-) xx[2]	Temperature in °C
:u<x> :u?	<x> = 0…1	--[1] or <x>[2]	Framecounter 0 = off, 1 = on
:v	--	Snr., Boot, App, FPGA[2]	Send snr and versions to PC
:V	--	Cameratype, ID[2]	Send cameratype and -ID to PC

1 If the command acknowledge flag is set the return will be ACK (0x06) or NAK (0x15).

2 The answer is followed by a CR (0x0d) trailer.

5.3. Read Camera Information

5.3.1. Read Serial Number and Firmware Revision

The serial number and the firmware revision can be read with the `:v` command.

Command	`:v`	
Response (example)	`#01234-B2.02-V2.02-F0.71`	
Description	`01234`	Serial number of the camera
	`B2.02`	Microcontroller bootloader firmware version
	`V2.02`	Microcontroller application firmware version
	`F0.71`	FPGA firmware version

5.3.2. Read Identifier

The serial number and the firmware revision can be read with the `:v` command.

Command	`:V`	
Response (example)	`0123456789123456`	
Description	`9123456`	Definition of additional functions or features, 4 bytes
	`5678`	Reserved bytes
	`01234`	Camera Type, e.g. 13620 = Baumer HXC13

5.3.3. Read Camera Temperature

To control the temperature inside, the camera disposes an internal temperature sensor. The temperature inside the camera can be read out in steps of 1°C.

The values are delivered in ASCII characters.

Command	`:T`
Response (example)	`34` followed by a CR (`0x0d`) trailer

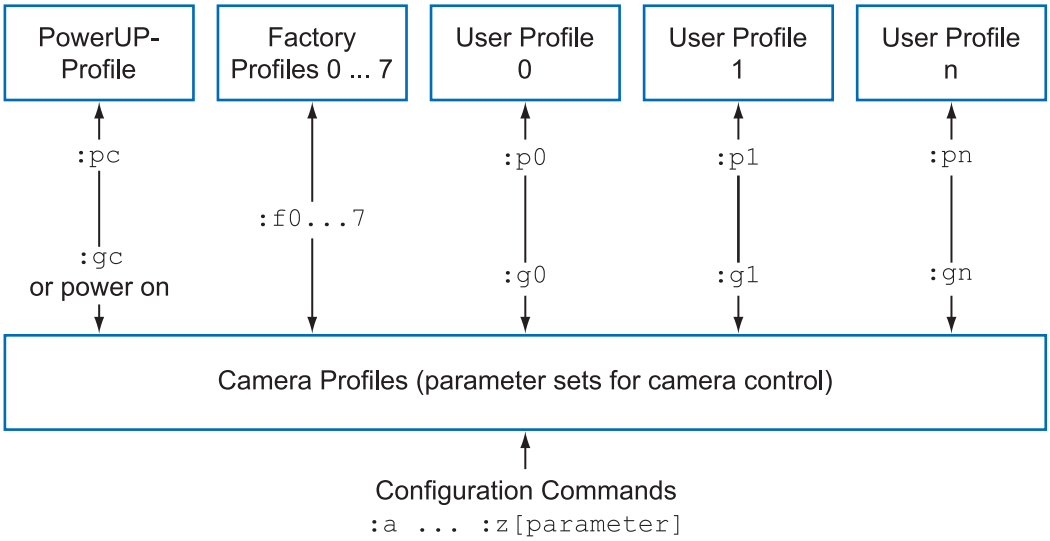
Notice

The temperature Sensor is able to deliver values of –128°C to +128°C.

Take care that the temperature of the camera does not exceed the specified case temperature range.

5.4. Profile Processing

All camera settings are loaded or stored as complete data blocks (profiles). There are 17 profiles - eight factory profiles, eight user profiles and a "PowerUpProfile".



◀ **Figure 5**
Profile processing for camera configuration.

5.4.1. Write User Profile

The current settings are transferred to one of the eight user profiles or the PowerUpProfile. Profile "c" is the PowerUpProfile.

Command	:p<n>	<n> = 0 ... 7, c

5.4.2. Load User Profile

Load one of eight user profiles or the PowerUpProfile to configure the camera.

Command	:g<n>	<n> = 0 ... 7, c

5.4.3. Load Factory Profile

The eight factory profiles can be read but not changed by the user.

Command	:f<n>	<n> = 0 ... 7

5.5. Output Mode

5.5.1. CameraLink® Output Mode

Command	:M<x>	<x> = 0 ... 6
	:M?	
Response	--*	* ACK/NAK if acknowledge on
	<x>	current value
Description	This command selects the camera output mode.	
	For example the mode 0 delivers 2 taps with 8 bit.	

Mode	Description	CameraLink® Configuration	Pixelclock	Remark
0	2x8	base	80 MHz	
1	2x10	base	80 MHz	
2	16x1	base	80 MHz	optional feature, binarization
3	2x8	base	80 MHz	optional feature, mask mode
4	4x10	medium	80 MHz	
5	8x8	full	80 MHz	
6	10x8	full	75 MHz	

5.5.2. Set Pixelclock

Command	:R<xx>	<xx> = $3c_{hex}$, 41_{hex}, 46_{hex}, $4b_{hex}$, 50_{hex}
	:R?	
Response	--*	* ACK/NAK if acknowledge on
	<x>	current value
Description	This command selects the pixelclock of the CameraLink® interface. As default all modes work with a pixelclock of 80MHz. (Except of mode 6 with 75MHz). With this setting the full speed of the camera can be achieved. The clock can be adjusted in 5 MHz steps from 60…80MHz.	
Application	Under some circumstances it is helpful to reduce the clock. This is the case if the framegrabber can't accept fast pixelclock or if a long or poor cable is used. Note that a reduced pixelclock results in a lower maximal framerate. This can be checked with the framerate command.	

Notice

In mode 6 the value 50_{hex} is not valid.

5.6. Image Quality

5.6.1. Digital Gain

Command	:D<xxxx>	<xxxx> = 0400 ... 1000_{hex}
	:D<x>	<x> = 0
	:D?	
Response	--*	* ACK/NAK if acknowledge on
	<xxxx>	current value
Description	The digital gain can be set from 0400_{hex} which is equivalent to gain 1x to 1000_{hex} which is equivalent to gain 4x. Setting the gain to 0 switches off the correction completely.	

5.6.2. Blacklevel

Command	:k<xx>	<xx> = 32 ... $C8_{hex}$
	:k?	
Response	--*	* ACK/NAK if acknowledge on
	<xx>	current value
Description	This command adjusts blacklevel. The value 80_{hex} is the factory calibrated default. Increase or decrease this value slightly to adjust blacklevel.	

5.6.3. FPN Correction

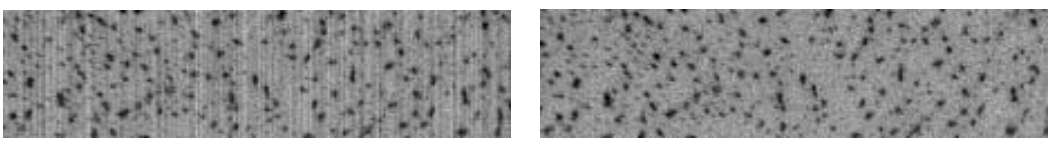
Command	:N<x>	<x> = 0 or 1
	:N?	
Response	--*	* ACK/NAK if acknowledge on
	<x>	current value
Description	With this command the column FPN (fixed pattern noise) correction can be activated or deactivated. At the beginning of each frame, before visible lines are read out, a fixed voltage is applied at the columns. These values are read out like real data and are stored inside the camera. When FPN correction is enabled the stored value is subtracted of each pixel. The advantage is a more homogeneous picture but with a limited dynamic.	

Notice

IThis noise is not dynamic but fixed (as the name says). That's a typical effect of a CMOS sensor. But the fixed pattern makes it easy to eliminate this noise completely.

The camera does only a column correction. If an accurate pixel correction of the full frame is required this must be done by the framegrabber or in the imaging software. To do this it's best to switch off the camera's FPN correction to get the original dynamic.

Then a complete image of a uniform area must be stored as a reference. This values must be subtracted for each pixel of the frame and the noise will disappear.



◀ **Figure 6**
Images captured without (left) and with activated FPN correction (right)

5.7. Image Size and Position

Image size and position within the Sensor is defined by four parameters:

Block	Description		Value Range
<aaa>	Address of first pixel	(x-start)	0 ... $4FE_{hex\ (modulo\ 24)}$
<bbb>	Address of first line	(y-start)	0 ... $3FE_{hex}$
<ccc>	x-width		2 ... $500_{hex\ (modulo\ modus)}$
<ddd>	y-height		1 ... 400_{hex}

5.7.1. Setting the Region of Interest (ROI)

Setting image size and position - region of interest (ROI):

Command	:d<aaa><bbb><ccc><ddd>	values as describes above
	:d?	
Response	--*	* ACK/NAK if acknowledge on current values
	aaabbbcccddd	

Notice

The x-start is rounded down if not modulo 24. The x-width has the modulo of the actual mode, e.g. 2, 4, 8 or 10. If the value does not fit the modulo the command will return NAK.

The ROI change time is 18 ms including command transfer at 115 kBaud. The new ROI is synchronized to the next frame so there is an additional delay of max 1 frameperiod.

For fast tracking purposes see also the ROI move mode.

5.7.2. Setting Multiple ROIs

Command	:L<z><xxx><yyy>	<z> = 1 ... 3 <xxx> = 0 ... $4fe_{hex}$ <yyy> = 0 ... $3fe_{hex}$	window to set x-start y-start
	:L<z>?	show current start of window <z>	
	:Ln<a>	<a> = 0 ... 3	windows to activate
	:Ln?	show number of active windows	
Response	– – *	* ACK/NAK if acknowledge on	
	xxxyyy	current value	
	a		
Description	With this command multiple ROIs are activated and controlled. Baumer HXC cameras allow to simultaneously choose up to three individual ROIs within the complete frame range. Thus, multiple objects can be captured independently at the same time. Normally only one window is active. This is the default of a = 0. With a > 1 up to 3 additional windows can be activated. So a total of maximal 4 windows can be active. Each window can have its own start address. The size of the additional windows is the same as the main ROI.		

Notice

The x-start has a modulo of 48 beginning with 0 or 24 depending on the main ROI. If multiple ROIs are active also the main ROI is locked to modulo 48. Start addresses not fitting this modulo will be automatically rounded by the camera and can be checked with the read command. Note also that when changing the size of the main ROI the additional ROIs will be changed automatically. So take care that these ROIs will fit into the sensor size. Also the maximum framerate will decrease if multiple win-dows are active.

This mode can not be combined with ROI move mode, x- or y- invert mode and mask mode.

5.7.3. Setting arbitrary shaped Fields of View

Command	:SC<xxx><yyy><rrr><www>	<xxx> = 0 ... 500_{hex}	<yyy> = 0 ... 400_{hex}
		<rrr> = 0 ... 300_{hex}	<www> = 0 ... 400_{hex}
	:SM<aaa><dddd>	<aaa> = 0 ... $3ff_{hex}$	<dddd> = 0 ... $ffff_{hex}$
	:SE		
	:SV<n>	<n> = 0...1	0 = off, 1 = on
Response	--*	* ACK/NAK if acknowledge on	

Description

Standard adjustment of the camera using the ROI parameters allows to define rectangular windows. For windows with different shapes the Baumer HXC cameras offer a feature to create arbitrary fields of view.

It can be adjusted by a selection mask consisting of 16.384 read tiles. Each tile has a size of 10(H) x 8(V). All 16.384 tiles cover the whole active sensor area with 128x128 tiles.

The camera has a built in algorithm to create a circle mask. With :SC a circle is created and all tiles that touch that circle are activated. With <xxx> and <yyy> the center of the circle is de-ined. The parameter <rrr> defines the radius and <www> defines the width. The circle can partially be out of the field of view. The internal calculation lasts <1 sec.

To create more arbitrary shapes the command :SM can be used. The first tile in first line is on address <aaa> = 0. Tile 16 is at address <aaa> = 1. The first tile in second line is at address <aaa> = 8. Each address covers 16 tiles that can be switched with the data <dddd>. For example to switch on the tile 16 and 18 in the second line use the command :SM009C000. The addresses can be randomly accessed and only that tiles that have to be activated must be written.

To erase all tiles use the :SE command.

For testing purposes the command :SV can be used. When in mode :M0 the activated tiles are viewed inverted in the picture but all pixels will be output.

To output only the activated tiles mode :M3 must be used.

The programmed settings are volatile and must be programmed new after each power up.

Notice

This mode can not be combined with ROI move mode, x- or y- invert mode and multiple ROI mode.

5.7.4. Setting arbitrary shaped Fields of View in Compatible Mode

Command	:r<$X_2X_1X_0$>	
	<$X_2X_1X_0$>	... range 000_{hex} ...$03ff_{hex}$
	<X_1X_0>	... selection byte, bits 7..0, range 00_{hex} ...$0ff_{hex}$
	<X_2>	... , bit 9..8 = 0: disable arbitrary window function
	<X_2>	... , bit 9..8 = 1: write 2048 selection bytes
	<X_2>	... , Bit 9..8 = 2: enable arbitrary window function, disable write selection byte function
Response	– – *	* ACK/NAK if acknowledge on
Description	Standard adjustment of the camera using the ROI parameters allows to define rectangular windows. For windows with different shapes the Baumer HXC cameras offer a feature to create arbitrary fields of view.	

It can be adjusted by a selection mask consisting of 16.384 read tiles. Each tile has a size of 10(H) x 8(V). All 16.384 tiles cover the whole active sensor area with 128x128 tiles.

The selected tiles are summed up in 2.048 selection bytes with 8 bit and can be loaded sequentially via register `r8`. Each set bit in a selection byte causes the associated tile to be captured and read out.

The first of 2048 selection bytes addresses the leftmost, top pixel group with 10 pixel in the 1.-8. line (1st selection tile). If bit 1 is set the next 10 pixel of line no. 1-8 are activated. Bit 7 enables pixel 70..79. The next selection byte, bit 0 addresses pixel 80..89.

To set the arbitrary shaped field of view all 2048 selection bytes must be written. In each byte at least write bit (bit 8) must be set. After all 2048 selection bytes have been programmed the write function must be finished by disabling the write function (2049. command).

The whole command list should be stored into a separate configuration file (*.mcf):

byte 1	byte 2...	byte n	byte n+1...	byte 2048	byte 2049
:r8100	:r8100...	:r81ff	:r81ff...	:r8100	:r8200

One command is only complete, if it starts with a colon, "`r8`" and then 2 ASCII characters. To get a better readability of the list it is recommended to start with a new line after 16 commands (CR+LF). The single commands `:r8200` and `:r8000` will enable and disable the function.

When in mode `:M0` the activated tiles are viewed inverted in the picture but all pixels will be output. To output only the activated pixels mode `:M3` must be used.

The programmed settings of the 2048 bytes are volatile and must be programmed new after each power up. The file may be written with the camera tool using the function "Write file to camera".

Notice

Do NOT use this command for new applications. Use the `:S` command instead.

5.7.5. ROI Move Mode with external CCx Input

Command	`:l<n><y>`	<n> = 0 ... 3 0 = off; 1 =y; 2 = x; 3 = x+y <y> = 1 ... f_{hex} step y-direction
	`:l?`	
Response	`--*`	* ACK/NAK if acknowledge on
	`<ny>`	current value

Description

This feature allows to move the actual ROI with the CC2…CC4 inputs of the CameraLink® interface. The signal can be generated by the framegrabber itself or by external signals that are input to the grabber. The stepping in x-direction is always 24 pixels, the stepping in y-direction can be selected from1-15 with the `<y>` parameter. Move will always be in positive direction. If the right side or the bottom of the sensor is reached no action will be on further input signals. With CC4 the position is reset to the original position; This is not necessarily the top left edge of the sensor.

Notice

The input frequency can be up to 20kHz. The signals will be added be-tween the frames. The added move signals are synchronized to the next frame. The internal process time is 500µs where no signals can be counted. This is immediately after the exposure meaning that signals input before 500µs after the falling edge of 'strobe' will be lost.

Signal

CC2 = y-increment
CC3 = x-increment
CC4 = reset to original position

Example

ROI 1280x390 pixel at 287fps and 1ms exposure time. Pulses with 20kHz.

There are 3ms time to send pulses. In this time 60 pulses can be sent from frame to frame.

So the possible 634 lines will take 38ms to move and 11 frames will be exposed in this time.

Notice

This mode can not be combined with multiple ROI mode, x- or y- invert mode and mask mode.

5.7.6. Invert Readout in x- and/or y-Direction

Command	:○<x>	<x> = 0 ... 3 0 = off; 1 =y; 2 = x; 3 = x+y
	:○?	
Response	– – *	* ACK/NAK if acknowledge on
	<x>	
Description	This feature allows to invert the frame readout in x- and or y-direction.	

Notice
This mode can not be combined with ROI move mode, multiple ROI mode and mask mode.

5.8. Frame Rate and Shutter

5.8.1. Setting the Frame Rate

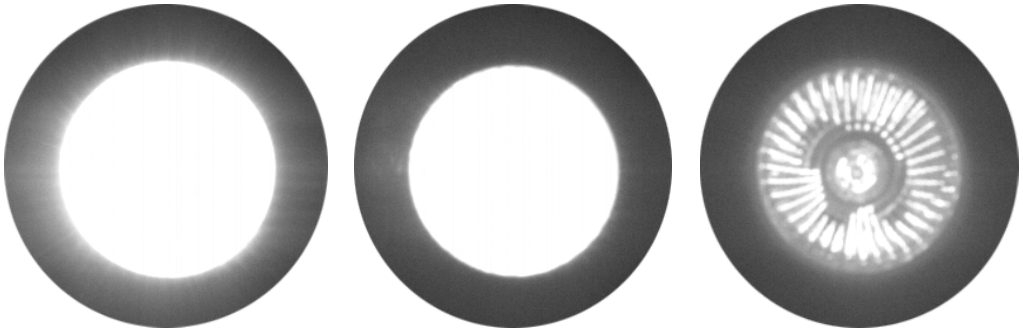
Command	:q<xxxxxx>	<xxxxxx> = 1 ... 13880_{hex}
	:q?	
Response	--*	* ACK/NAK if acknowledge on
	<xxxxxx>' '<ss>'-'<zzzzzz>	<xxxxxx> current value
		<ss> minimal value
		<zzzzzz> maximal value
Description	This command sets the framerate in free run mode. The valid range depends on ROI and tap mode and can be obtained with '?' as parameter.	

5.8.2. Setting the Exposure Time (Shutter)

Command	:t<xxxxxx>	<xxxxxx> = 1 ... $F4240_{hex}$
	:t?	
Response	--*	* ACK/NAK if acknowledge on
	<xxxxxx>' '<ss>'-'<zzzzzz>	<xxxxxx> current value
		<ss> minimal value
		<zzzzzz> maximal value
Description	This command sets the shuttertime in free run and sync with timer mode. Depending on the tap mode and ROI the minimal and maximal shuttertime can vary. Use the '?' parameter for the valid range. The maximal exposure time is 1/framerate.	

5.8.3. Setting the Slopes for High Dynamic Range (HDR)

Command	`:i<s><x>`	<s> = 'n' → <x> = 1 ... 3	(No. of slopes)
	`:i<s><xx>`	<s> = 'd','t' → <xx> = 1 ... 63_{hex}	('d'ual or 't'riple slope in percent)
	`:i<s>?`		
Response	`--*`	* ACK/NAK if acknowledge on	
	`<x>`	Number of slopes	
	`<xx>' '<yy>-<zz>`	<xx> current value	
		<yy> minimal value	
		<zz> maximal value	
Description	This command sets the multiple slope function for dynamic range adjustment. Through two selectable steps, the camera's dynamic range adjustment option allows to approach the CMOS sensor's linear range into a dynamic range corresponding to the nonlinear human eye. Consequently, Baumer HXC cameras provide definite image details even in case of extreme dark-light contrasts, which means an invaluable benefit exceptionally in image proc-essing. With `'n' = 1` the multiple slopes are deactivated and the frame will be exposed with the whole shut-tertime. With activated slopes the bright pixels will be reset after `<xx>`percent of the shuttertime. The dual value must be smaller than triple. Depending on the mode, ROI and shuttertime the first slope can eventually not start at `1` percent. The valid range can be read out with the `'?'` argument. Only if valid values are set the function can be activated. See also `'last error'` command.		



◀ **Figure 7**
Images of a 50W spot-light.
From left to right: without dynamic range, with dynamic range dual slope and with dynamic range tripple slope.

5.8.4. Non destructive Readout for multiple Pixel Exposure

Command	:O<x>	<x> = 1 ... 7
	:O?	
Response	– – *	* ACK/NAK if acknowledge on
	<x>	current value
Description	This command controls the non destructive readout mode. If desired, pixel exposure can be accumulated up to 7 times, resulting in alternative image exposures. The optimally exposed image can be selected for further processing. At indefinite lighting conditions, as in 24 hour outdoor applications, the Baumer HXC becomes the high speed camera that spots everything. With x = 1 after every frame the pixels are reset (normal operation). With x > 1 all pixels will be read out multiple times (max. 7) after they are reset. So for low light the last samples are useful and for high light levels the first samples are useful.	

5.9. Exposure Control

Command	Description
:h	Type of exposure
:H	Edge select
:t	Exousure Time

5.9.1. Type of Exposure

Baumer HXC cameras can expose the images in free run mode or with an external signal on CC1. The external modes are used to synchronize the cameras to each other or to an external event. See also the timing diagrams in the technical data section of this manual.

The following commands select exposure type:

Mode Description	Mode	Edge	Exposure Time
Free run with electronic shutter	:h0	--	:t<xxxxxx>
Pulsewidth, positive edge	:h1	:H0	Pulsewidth
Pulsewidth, negative edge	:h1	:H1	Pulsewidth
External sync with internal timer, positive edge	:h2	:H0	:t<xxxxxx>
External sync with internal timer, negative edge	:h2	:H1	:t<xxxxxx>

5.9.2. Free run with electronic Shutter

In free run mode the framerate and shuttertime can be selected with camera settings. Depending on tap mode and ROI the framerate can be set from 1…120000 fps and the exposure time can be set from 2µs to 1s.

5.9.3. Pulsewidth Mode

In this mode an external signal starts exposure and the exposed image is output immediately after the exposure ends. Exposure time is defined by an internal timer. The exposure of the next image can be started while the last image is transferred or at a later time.

5.10. Other

5.10.1. In Frame Counter

Command	:u<x>	<x> = 0 ... 1
	:u?	0 = off; 1 = on
Response	--*	* ACK/NAK if acknowledge on
	<x>	current value
Description	If a sequence of frames is to be recorded for long time at a high frame rate, it can be useful to mark the images for later identification or check for completeness. Baumer HXC cameras have a 16-Bit image counter whose count can replace the first two pixel of every image. It is incremented by every new image.	

5.10.2. Test Image

Command	:n<x>	<x> = 0 ... 1	0 = power down + test image
	:n?		1 = normal operation
Response	--*	* ACK/NAK if acknowledge on	
	<x>	current value	
Description	For testing of camera logic and video data transmission, sensor data can be replaced by an internal gray scale pattern with pixel values of 0 ... 255. With x = 0 the camera sends the gray-scale. This mode can also be used to save power consumption.		

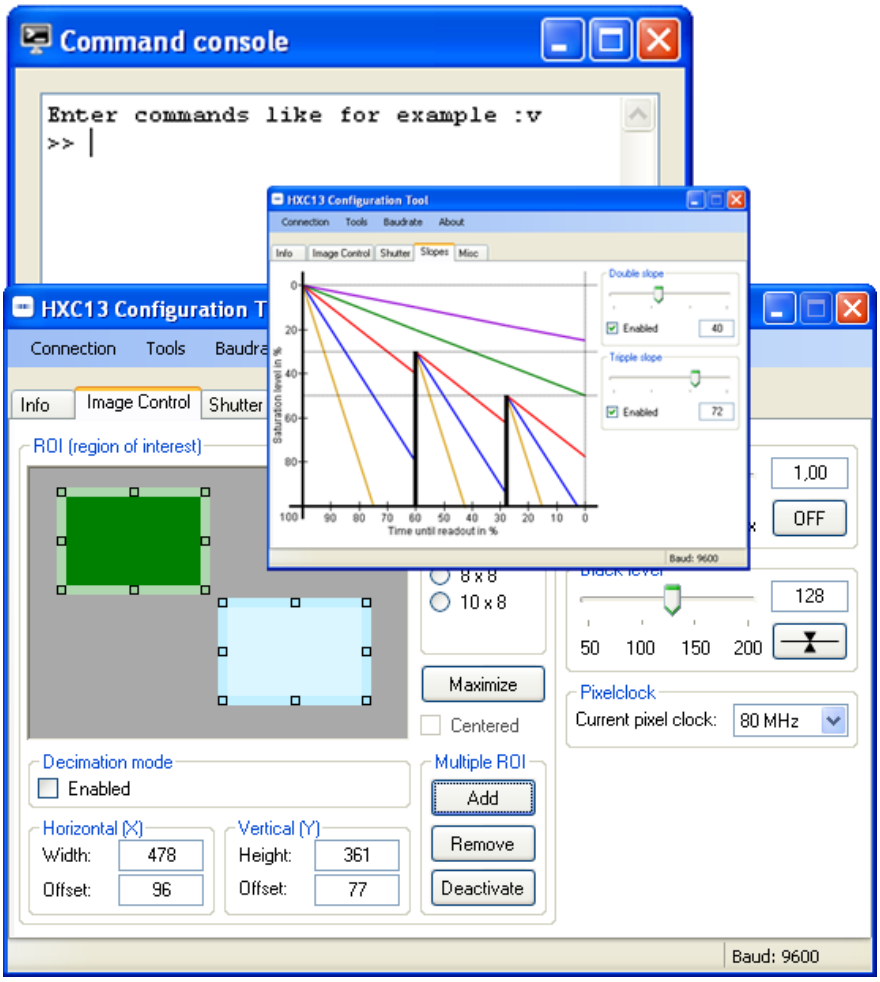
5.10.3. Get last Error

Command	:B
Response	'OK' or 'ERROR: xx message'
Description	With this command the status of the camera after power up or the last command can be read out. If a command returns NAK maybe the reason can be found.

5.10.4. Reset and Configuration of the internal FPGA

Command	:c	
Response	--*	* ACK/NAK if acknowledge on
Description	The command :c executes a reset in the camera. The FPGA will be reconfigured and all internal registers reloaded with the last saved PowerUpProfile. The FPGA is also configured after each power up.	

6. Baumer HX Series Configuration Tool



◀ **Figure 8**
Screenshots of Baumer HX Series Configuration Tool.

The Baumer HX Series Configuration Tool must be installed on a Windows® PC by means of the setup software.

Notice

The software is available for Windows® 32 bit as well as for Windows® 64bit operating systems.

Requirements:

- Microsoft® .NET™ 2.0 Framework
- cl_____.dll for the Frame Grabber board

This software provides an almost self explaining user interface to modify any camera parameter. The description of the parameters follows the marked chapters in this user's guide. Please note the User´s guide "Baumer HXC13 Configuration Tool"

The peviously stated commands can also be entered directly to the "commands console".

To use this tool with Baumer HXC cameras, the serial interface is integrated in the CameraLink® interface. You do not need any other additional cable.

7. Technical Information

7.1. Sensor Defect Specifications

Parameter	Description	Limit
BrightPix	Amount of bright pixels (response higher then half scale) in a dark image. Dark image must first be FPN corrected.	< 10
DarkMeanOutput	Average value of a dark image (10-bit scale).	0 < x < 235
50%MeanOutput	Average value of a half scale image (10-bit scale).	390 < x < 547
FPN	Fixed pattern noise of a dark image should be smaller than 3.1% of the signal swing	< 3.1%
TotDefects	Amount of defect pixels in a half scale image. A defect pixel is defined as a pixel that has a response that is 20% off the median response of all pixels. The half scale image must be FPN corrected.	< 20
BadColumnOutput	Amount of bad columns in a half scale image. A bad column is defined as a column that has a response that is 10% off the median of the surrounding 40 columns. The half scale image needs to be FPN corrected.	0
BadRow	Amount of bad rows in a half scale image. A bad row is defined as a row that has a response that is 10% off the median of the surrounding 40 rows. The half scale image needs to be FPN corrected.	0
Cluster	Amount of clusters allowed See note.	0
Coverglass Dig/Scratch	Uniform illumination. Test sensor for defective pixels. Defects on cover glass will generate defect pixels. No defect pixels may be visible.	0

Measurement Conditions
Illumination source: High brightness led light source (white) Using a pinhole to imitate the lens setup in the application. F=5.4
Temperature is 25ºC (logged during the test program) and 30 ºC on wafer. Dark current limit is set at 30 ºC
Definition of operation conditions: Nominal clock frequency is 310 MHz. Unity Gain Power supplies as specified in the datasheet (recommended operation conditions) Integr. times: Dark image short IT: 4µs, Dark image long IT: 1s, Other images: 2ms

Notice

A cluster is defined as a group of minimal 2 and maximum 4 neighboring defect pixels (top, bottom or side; not diagonal). Clusters that exceed the maximum of 4 defect pixels are not allowed at all.

7.2. CameraLink® bit Assignments

7.2.1. Base CameraLink® 2x8/10 - bit Assignment

The following table shows the bit assignment of two adjacent pixel, eight or ten bits each. All unused bits are set to logical LOW level, the SPARE outputs are set to logical HIGH level.

Plug 1, CameraLink® X, 2x8-bit			Plug 1, CameraLink® X, 2x10-bit		
Port	Tx	Signal	Port	Tx	Signal
A0	0	D0	A0	0	D0
A1	1	D1	A1	1	D1
A2	2	D2	A2	2	D2
A3	3	D3	A3	3	D3
A4	4	D4	A4	4	D4
A5	6	D5	A5	6	D5
A6	27	D6	A6	27	D6
A7	5	D7 (msb)	A7	5	D7
B0	7	D8	A8	7	D8
B1	8	D9	A9	8	D9 (msb)
B2	9	D10	LOW	9	LOW
B3	12	D11	LOW	12	LOW
B4	13	D12	B8	13	D18
B5	14	D13	B9	14	D19 (msb)
B6	10	D14	LOW	10	LOW
B7	11	D15 (msb)	LOW	11	LOW
LOW	15	LOW	B0	15	D10
LOW	18	LOW	B1	18	D11
LOW	19	LOW	B2	19	D12
LOW	20	LOW	B3	20	D13
LOW	21	LOW	B4	21	D14
LOW	22	LOW	B5	22	D15
LOW	16	LOW	B6	16	D16
LOW	17	LOW	B7	17	D17
LVAL	24	LVAL	LVAL	24	LVAL
FVAL	25	FVAL	FVAL	25	FVAL
DVAL	26	DVAL	DVAL	26	DVAL
SPARE	23	HIGH	HIGH	23	HIGH
	TxCLK			TxCLK	

7.2.2. Full CameraLink® 8x8 - bit Assignment

The following table shows the bit assignment of eight adjacent pixel. All unused bits are set to logical LOW level, the SPARE outputs are set to logical HIGH level.

Plug 1, CameraLink® X			Plug 2, CameraLink® X			Plug 2, CameraLink® Z		
Port	Tx	Signal	Port	Tx	Signal	Port	Tx	Signal
A0	0	D0	D0	0	D24	G0	0	D48
A1	1	D1	D1	1	D25	G1	1	D49
A2	2	D2	D2	2	D26	G2	2	D50
A3	3	D3	D3	3	D27	G3	3	D51
A4	4	D4	D4	4	D28	G4	4	D52
A5	6	D5	D5	6	D29	G5	6	D53
A6	27	D6	D6	27	D30	G6	27	D54
A7	5	D7 (msb)	D7	5	D31 (msb)	G7	5	D55 (msb)
B0	7	D8	E0	7	D32	H0	7	D56
B1	8	D9	E1	8	D33	H1	8	D57
B2	9	D10	E2	9	D34	H2	9	D58
B3	12	D11	E3	12	D35	H3	12	D59
B4	13	D12	E4	13	D36	H4	13	D60
B5	14	D13	E5	14	D37	H5	14	D61
B6	10	D14	E6	10	D38	H6	10	D62
B7	11	D15 (msb)	E7	11	D39 (msb)	H7	11	D63 (msb)
C0	15	D16	F0	15	D40	LOW	15	LOW
C1	18	D17	F1	18	D41	LOW	18	LOW
C2	19	D18	F2	19	D42	LOW	19	LOW
C3	20	D19	F3	20	D43	LOW	20	LOW
C4	21	D20	F4	21	D44	LOW	21	LOW
C5	22	D21	F5	22	D45	LOW	22	LOW
C6	16	D22	F6	16	D46	LOW	16	LOW
C7	17	D23 (msb)	F7	17	D47 (msb)	LOW	17	LOW
LVAL	24	LVAL	LVAL	24	LVAL	LVAL	24	LVAL
FVAL	25	FVAL	FVAL	25	FVAL	FVAL	25	FVAL
DVAL	26	DVAL	DVAL	26	DVAL	DVAL	26	DVAL
SPARE	23	HIGH	SPARE	23	HIGH	SPARE	23	HIGH
	TxCLK			TxCLK			TxCLK	

7.2.3. Full CameraLink® 10x8 - bit Assignment

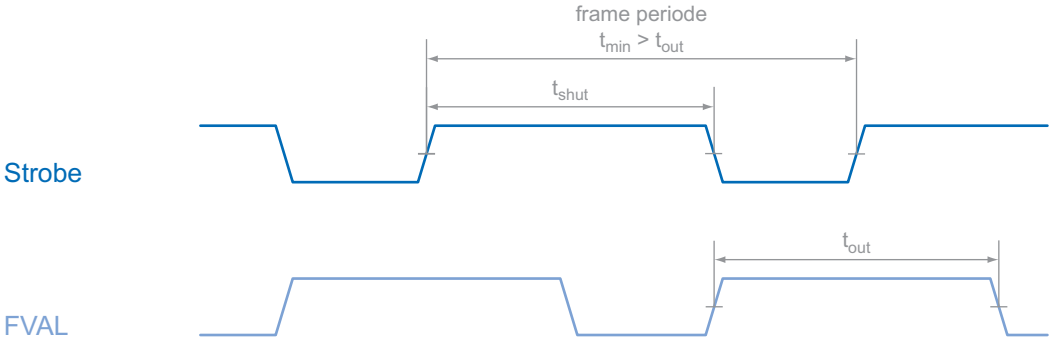
The below table shows the assignment of 10 adjacent pixel, 8-Bit each. This assignment is compatible to Baslers A504 camera.

Plug 1, CameraLink® X			Plug 2, CameraLink® X			Plug 2, CameraLink® Z		
Port	Tx	Signal	Port	Tx	Signal	Port	Tx	Signal
A1	0	D0_0	D3	0	D3_2	G6	0	D6_5
A2	1	D0_1	D4	1	D3_3	G7	1	D6_6
A3	2	D0_2	D5	2	D3_4	G8	2	D6_7 (msb)
A4	3	D0_3	D6	3	D3_5	H1	3	D7_0
A5	4	D0_4	D7	4	D3_6	H2	4	D7_1
A6	5	D0_5	D8	5	D3_7 (msb)	H3	5	D7_2
A7	6	D0_6	E1	6	D4_0	H4	6	D7_3
A8	7	D0_7 (msb)	E2	7	D4_1	H5	7	D7_4
B1	8	D1_0	E3	8	D4_2	H6	8	D7_5
B2	9	D1_1	E4	9	D4_3	H7	9	D7_6
B3	10	D1_2	E5	10	D4_4	H8	10	D7_7 (msb)
B4	11	D1_3	E6	11	D4_5	I1	11	D8_0
B5	12	D1_4	E7	12	D4_6	I2	12	D8_1
B6	13	D1_5	E8	13	D4_7 (msb)	I3	13	D8_2
B7	14	D1_6	F1	14	D5_0	I4	14	D8_3
B8	15	D1_7 (msb)	F2	15	D5_1	I5	15	D8_4
C1	16	D2_0	F3	16	D5_2	I6	16	D8_5
C2	17	D2_1	F4	17	D5_3	I7	17	D8_6
C3	18	D2_2	F5	18	D5_4	I8	18	D8_7 (msb)
C4	19	D2_3	F6	19	D5_5	J1	19	D9_0
C5	20	D2_4	F7	20	D5_6	J2	20	D9_1
C6	21	D2_5	F8	21	D5_7 (msb)	J3	21	D9_2
C7	22	D2_6	G1	22	D6_0	J4	22	D9_3
C8	23	D2_7 (msb)	G2	23	D6_1	J5	23	D9_4
LVAL	24	LVAL	G3	24	D6_2	J6	24	D9_5
FVAL	25	FVAL	G4	25	D6_3	J7	25	D9_6
D1	26	D3_0	G5	26	D6_4	J8	26	D9_7 (msb)
D2	27	D3_1	LVAL	27	LVAL	LVAL	27	LVAL
	TxCLK			TxCLK			TxCLK	

7.3. Timing Diagrams

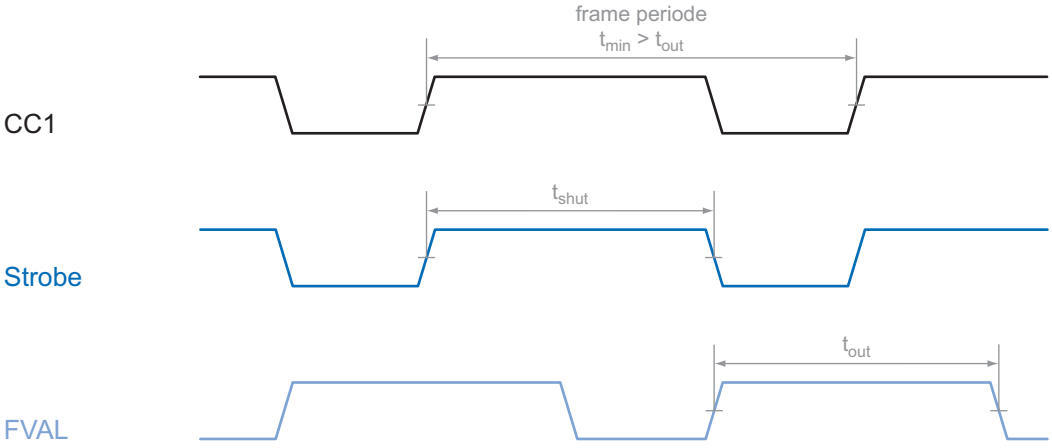
7.3.1. Free Run with electronic Shutter

In this mode frame rate and exposure time is controlled by the camera. At the strobe output (in power connector) there is a high signal while the camera exposes a picture.



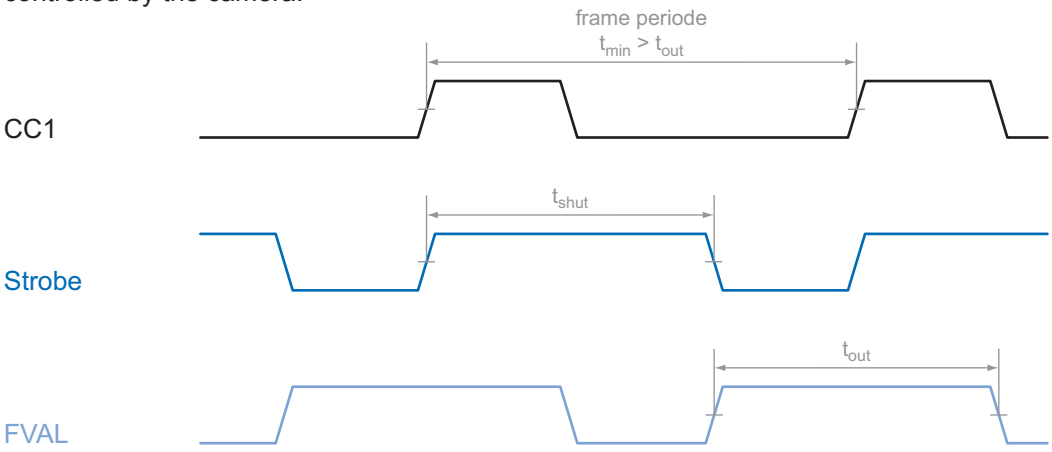
7.3.2. Pulsewidth Mode

In this mode frame rate and exposure time is controlled by the framegrabber with the CC1 (Camera Link®) camera input. The time t_min (that defines the frame rate) must not be smaller than t_out (which is the output time for one frame).



7.3.3. External Synch with internal Timer

In this mode the frame rate is controlled by the framegrabber while the exposure time is controlled by the camera.



8. Support

If you have any problems with the camera, then feel free to contact our support.

Worldwide

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